Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington DC 20554

In the matter of:	)	
	)	
ADMENDMENT OF PART 97 OF THE	)	**RM-11392**
COMMISSION'S RULES GOVERNING THE	)	
AMATEUR RADIO SERVICE TO	)	
IMPLEMENT CHANGES TO SECTION 97.3(C)(2),	)	
97.221 AUTOMATICALLY CONTROLLED	)	
DIGITAL STATION	)	
97.305 AUTHORIZED EMISSION TYPES,	)	
97.307 EMISSION STANDARDS, AND	)	
97.309 RTTY AND DATA EMISSION CODES	)	

Reply Comments Regarding the Petition to modify Part 97 Rules and Regulations for automatically controlled digital stations, authorized emission types, emission standards, and RTTY and data emission codes.

My name is James G. Gorman, Amateur Radio callsign WA0LYK, and I am a licensed amateur radio operator I have been active in amateur radio since 1964. I graduated from the University of Kansas in 1972 with a BSEE.

INTRODUCTION

Many people filing comments appear to not have read the petition at all. Many of the reply comments against the petition contain no factual information or data supporting the conclusions made. These should be considered as unsupported assertions and given no weight.

I have arranged the following into sections grouped by the person making comments. In all cases, there are multiple comments or claims by each person.

Comments by Jason C. Cato

“The RM-11392 petition seeks to destroy digital data technology advancement in the Amateur Radio Service.”

There is no data or background information to substantiate such claims. Consequently, it is impossible to address the conclusion directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

However, if one simply looks at the number of data protocols and applications being introduced to the Amateur Service almost monthly this claim is entirely frivolous. Never before have so many protocols, applications and transmission techniques for digital data communications been available to the amateur radio operator at what is in essence, no cost.
Modes such as WSJT and Olivia and applications such as NBEMS and pskMail are relatively recent additions and all use digital data technology.

Conclusions such as this with no supporting information are simply an emotional appeal with the hope that somehow it will “sway” someone into making an uninformed decision.

“The RM-11392 petition's proposed 1.5kHz bandwidth limit on data emission is too narrow for established international standard transmissions and equipment bandwidths used by the Amateur Radio Service.”

This claim does not list the international standards that amateur radio can not meet without access to wider bandwidths. There is no data or background information to substantiate such claims. Consequently, it is impossible to address the conclusion directly and therefore should should not be considered as providing any substantial information one way or the other.

“The RM-11392 petition is an attempt to kill innovation, technology advancement, and emergency data communications in the Amateur Radio Service. Please do not let this happen.

There is no data or background information to substantiate such claims. Consequently, it is impossible to address the conclusion directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

“The FCC Amateur Radio Service's automatically controlled data sub-bands are already too narrow for the huge volume of traffic that runs on them. If a limit of 1.5kHz bandwidth is applied, it will

severely hamper the ability of amateur radio operators to share these small band segments efficiently through rapid data methods."

There is no data or background information to substantiate such claims. There is no usage studies, interference information, operational techniques, etc. discussed at all. Consequently, it is impossible to address the conclusion directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

"There is a huge installed base of Amateur Radio Equipment, and millions of dollars of monetary investment by thousands of Amateur Radio Operators that use HF digital data systems with more than 1.5kHz bandwidths. This investment by FCC-licensed operators would be taken away or rendered useless if the objectives of the RM-11392 petition were to be adopted."

There is no data or background information to substantiate such claims. No equipment is mentioned by manufacturer or type and therefore it is impossible to address this claim. In fact, one has to wonder if this commenter even read the petition. Mr. Miller explicitly states that Pactor III modems, assuming this is what the commenter is discussing, will continue to be able to be used, albeit at smaller speed levels. Consequently, it is impossible to address the conclusion directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

"Several of the primary established HF emergency communications networks currently in service and utilized by thousands of Amateur Radio Operators in USA would be totally eliminated or hobbled if the objectives of the RM-11392 petition were to be adopted."

There is no data or background information to substantiate such claims. No information is provided about what networks would be eliminated or how they would be hobbled. Consequently, it is impossible to address the conclusion directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

"The Amateur Radio Service relies upon international communications standards. Many of the present digital data communications standards require bandwidths in excess of 1.5kHz. The normal amateur radio service bandwidth limit by governments of other countries is 6kHz."

The commenter appears to be asking for the rtty/data bandwidth limit to be changed to 6 kHz. There are no studies, data, or impact analysis to support this request. Consequently, it is impossible to address the request directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

"Thousands of licensed Amateur Radio Operators would be disenfranchised if the objectives of RM-11392 were to be adopted."

There is no data or background information to substantiate such claims. The commenter does not even define what he means by "disenfranchised". Consequently, it is impossible to address the conclusion directly and therefore should be dismissed because it does not add to the dialog necessary to making a decision.

"The RM-11392 petition is comparatively similar to an Analog Cellular Phone service entity trying to eliminate newer Digital Cellular Phone service. The fact is, Amateur Radio is now using faster time-multiplexing digital methods to enable more stations to efficiently use the same frequency channels simultaneously or in rapid succession. These time division techniques require at least 3kHz of bandwidth."

Again, we have a conclusion but no supporting information from which to make a decision. In fact, some of the claims are simply incorrect. The commenter does not explain exactly what modes/protocols/transmission techniques are using time-multiplexing digital methods. If the commenter is discussing Pactor 3, then he is mistaken. Pactor 3 uses dedicated sessions between a client and an automatic station and access to the automatic station is sequenced in time, one client after another. This is not considered to be time-multiplexing.

Comments submitted by Gerald F. (Rick) Muething, KN6KB, AAA9WK

"Re: Mr. Miller's comment. "Pactor III is designed specifically for the commercial market"

This comment is not true and not supported by any historical facts. Pactor III (and Pactor II and Pactor I) were designed by Radio amateurs at SCS (Germany). Pactor I was released to the public domain and used by several Amateur modem manufactures. Pactor II and III are and have been used by the amateur radio community world wide for many years primarily because these modes offer the best available performance (robustness and throughput) of any available "error free" digital protocol. The basic modulation mechanisms of Pactor II and III (OFDM, multi carrier PSK modulation) are well understood by those familiar with the digital modulation and are not proprietary. Only the specific implementation and protocol of Pactor II and III are proprietary to SCS and are what is licensed by their modems and firmware. ***Pactor III was designed to comply with the US Amateur maximum symbol rate (now considered an obsolete/unnecessary regulation). Pactor III is used in some commercial applications (as is Pactor I and II and other amateur protocols) but the product and protocol was not designed specifically for commercial applications."***

This claim by Mr. Muething is not supported by documentation contained at the manufacturer's web site. The manufacturer of these modems is SCS, Special Communications Systems GmbH & Co. KG, Roentgenstr. 36, 63454 Hanau, Germany. At the site is a document entitled “The PACTOR-III Protocol” authored by Hans-Peter Helfert and Thomas Rink. The document has been provided as Appendix A. The document states the following:

“While PACTOR-I and -II were developed for operation within a bandwidth of 500 Hz, PACTOR- III is designed specifically for the commercial market to provide higher throughput and improved robustness utilizing a complete SSB channel.”

This statement by the manufacturer amply demonstrates that Pactor III was not designed to comply with the US Amateur maximum symbol rate as claimed by Mr. Muething. It was designed for the commercial marketplace where an entire SSB channel bandwidth is assumed to be available.

Mr. Muething's comment that the current US Amateur maximum symbol rate is now considered an obsolete/unnecessary regulation amply points out that the FCC needs to address the issues contained in Mr. Miller's petition because many current US Amateur Radio operators do not consider the limits as written in the Part 97 rules to be an impediment to implementing wider and wider bandwidths.

These statements are obviously incorrect and should be ignored.

“Re Mr. Millers statement: “During optimal conditions the bandwidth (of Pactor III) increases from 500Hz to 2.2 KHz without determining if the wider spectrum is occupied”

Is incorrect. Pactor III’s bandwidth is 1000 to 2200 Hz from speed level 1 – 6. In normal operation (with the exception of extremely low S/N or very poor multipath) Pactor III operates in speed levels 3 – 6 occupying a bandwidth of 1720 – 2000 Hz. In at least the Winlink system of US stations there are no situations where Pactor III and other Pactor levels are used on the same frequencies. Any attempt to connect to a Pactor III server using Pactor II or Pactor I is immediately (<5 seconds) disconnected.”

The same technical description referenced above has the following statement:

“As the FSK PACTOR standard is used for the initial link establishment, frequency deviations of the connecting stations of up to +/–80 Hz are still tolerated.”

FSK PACTOR is commonly called Pactor I and this term is used by Mr. Muething. As the technical description states, all Pactor communications using SCS modems begin in Pactor I, a mode that is <500 Hz. Therefore, Mr. Millers, description of Pactor III, while not quite technically complete, is accurate. These link establishment calls can last a considerable time (minutes) if an automatic station is not available to answer. Therefore, to other users of the amateur spectrum, it DOES appear as if the mode simply swells from <500 Hz to one that is up to 2.2 kHz without warning.

This statement is obviously incorrect and should be ignored.

"Re. Mr. Millers statement: "To date there have been no technical innovations to minimize interference"

Is incorrect. Specifically the current firmware in the SCS PTC II class modem includes an effective DSP based busy detector that can detect Pactor activity in the channel to low S/N levels. This detector is not perfect (just as the human ear is not perfect in detecting signals at low S/N levels) but it is useful and effective. This "busy detector" is currently used both in clients and server programs (e.g. AirMail, Paclink MP, etc) that use Pactor II and III to reduce the chance of interference to existing Pactor sessions on the same (or near) frequencies."

This statement has been contradicted numerous times by Mr. Waterman, K4CJX, the Winlink2K system administrator while making comments on the yahoo group "wl2kemcomm". Here is a question by a member of the forum and the answer by Mr. Waterman on the referenced forum about "busy detection" on Winlink2K stations:

>Date: Sun, 30 Dec 2007 17:38:30 -0600
>Subject: RE: [wl2kemcomm] Re: Comments about RM-11392
>Reply-To: wl2kemcomm@yahoogroups.com
>
>Rick, All,
>
>IT was attempted with the old Winlink system.
>However, malicious interference on a continual
>basis kept the auto-start stations from
>transmitting and it was therefore
>eliminated. Things are even worse today on the
>Ham bands and I have absolutely NO confidence
>that busy signal detection will be successful
>regardless of the technical merits.
>
>
>Steve, k4cjx
>
>
>
>>From: wl2kemcomm@yahoogroups.com
>[mailto:wl2kemcomm@yahoogroups.com] On Behalf Of wa5lqz
>Sent: Sunday, December 30, 2007 1:41 PM
>To: wl2kemcomm@yahoogroups.com
>Subject: [wl2kemcomm] Re: Comments about RM-11392
>
>Steve k4cjx and WDT
>

>How are chances of the auto busy detection being
>tried again for the PMBOs. This would go a long
>way in showing our desire to cooperate with other
>users. If it draws interference again
>then at least we have tried to get along.
>
>This seems to be a major issue in my area.
>
>Thanks
>Alan wa5lqz
>
>

As can be seen, it is obvious that the system administrators have turned off all busy detection schemes that would normally be available.

Mr. Muething's statement is obviously incorrect and should be ignored.

"One poor operating practice involves using a client to manually initiate a call to another (automatic answering) station without carefully listening for a open channel (or subverting the busy detector). One only has to listen to the SSB phone bands to know this poor practice is not limited to digital transmissions. In semi automatic systems the automated end of the link NEVER initiates a call and responds only after it receives and successfully decodes a connect request. While interference can be caused from the automated station when there is a hidden transmitter (the manual station cannot hear a third station when the third station can hear the automated station) this is a relatively infrequent condition.

The second poor operating practice that results in interference is the use of wide band (panoramic) receivers (usually using sound card and DSP technology) to operate with narrow band modes. Such practices subvert the benefits of narrow band modes by operating the receivers "wide open" which results in un necessary interference when adjacent (but non overlapping) interfering signals exist in the wide pass band. Simply narrowing the receiver bandwidth to a value consistent with the narrow band mode would significantly reduce much of this type of "interference"."

Mr. Muething's statement that hidden transmitter interference is relatively infrequent is simply not backed up with any supporting data or information. There is nothing to analyze in order to determine just what "relatively infrequent" means. Is it <49% of the interference that occurs or <1%. This claim simply can not be supported and should be ignored.

Mr. Muething's statement that much of the interference from an adjacent channel Pactor signal could be eliminated does nothing to categorize how much of the interference problems associated with Pactor signals fall into this area. Without supporting data to assess this claim it adds nothing to the discussion and must be ignored.

Comments submitted by Steve Waterman, K4CJX

"The issue today, and for the future, is that the most efficient high speed digital data transfer protocols with the smallest relative footprint, use a bandwidth over 500 Hz, are generally under local or remote control (semi-automatic,) and are therefore constrained by Part 97.221. These narrow bandwidth segments listed in Part 97.221(b),[2] which contain stations over 500 Hz under local or remote control, are extremely limiting, and there is literally no room for current operations, much less for future digital enhancements to the radio art. Further limiting their availability by limiting their bandwidth to less than is currently authorized, and continuing to restrict the spaces in which they operate, is certainly not consistent with the future development of such protocols."

This statement would have one believe that the only viable alternative Amateur Radio has for "future digital enhancements" is to allow automatic stations more room to operate. Mr. Waterman fails to deal with system design and enhancements that can be done in this area. More space seems to be the only solution Mr. Waterman believes can solve the problem. There are other solutions.

Mr. Waterman would hope that everyone is confused and equates the number of users of the Winlink2k email service to an "enhancement to the radio art" as he does. "Enhancements to the radio art", as he calls it, is not measured by the number of users subscribing to a free email service. It is measured simply by the technology being used, not how many people use it.

In the end, if someone takes more space from a finite commons area, then someone must also give up space. Mr. Waterman has not addressed this issue other than from a self-absorbed position that the "service" he is involved with needs more space. That little consideration has been given to other amateur operators is obvious by his omission of even addressing the issue. It's almost like he is saying "my use of the amateur spectrum is more important than yours, therefore all I need to show is that I need more space". This is not spectrum used by common carriers jockeying for more and more spectrum for the products they offer, it is Amateur Radio spectrum and is shared by all equally. One basic rule contained in Part 97 is that "No frequency will be assigned for the exclusive use of any station." Corollaries to this are that no one is guaranteed either a time or a space to operate. Mr. Waterman needs to address these issues before asking for more space for "his" service.

There are other solution to the need for more space other than wider automatic sub-bands and wider data emissions. One of the oldest data modes in use on the amateur bands is AX.25. This mode allows multiple stations to share the same frequency. Most people consider it somewhat slow, however, it has seen no "technological innovation" in decades. Perhaps limiting space will spur new technical designs that can provide a faster, better sharing mechanism. We will never know if this will happen if bandwidths and band space is just continually expanded to accommodate faster, wider commercial off the shelf modems. The old adage, that necessity is the mother of invention is an appropriate one.

Other solutions can be administrative. The day to day email traffic being handled by the Winlink2K system is just amateur traffic after all. It is neither guaranteed a time or a space to occur in. One simple solution would be to have alternate letters of the call signs handle email on alternating days, that is A, C, E, etc. on one day and B, D, F, etc. on the next day. Exemptions could be handled for amateurs with especially significant emails.

The Winlink2k email service is a system. The system can be changed to make it more efficient and to minimize the impact on other amateurs. It is the responsibility of the Winlink2K system to provide the information and data to the FCC that allows their attempts to make the system more efficient to be assessed prior to simply making a claim that more space is needed. The FCC should not consider rewarding an inefficient network in any way.

“Mr. Miller suggests that Pactor 3, with a maximum bandwidth of 2.4 KHz, is unsuitable for the Amateur service, and suggests that it was developed for Commercial operations. Nothing could be further from the facts. That is, no more than voice SSB, with a bandwidth of approximately 2.4 to 3.0 KHz is not suited for Amateur radio or should be deemed commercial. American and German Amateur radio operators4 developed all three Pactor protocols for use in the Amateur spectrum, and due to its l 100 baud symbol rate, and successful robust implementation within the Amateur ranks, has also found use by our own Federal, States and Counties Government, Private Coastal maritime associations, and with thousands of Amateurs, who wish to utilize the most efficient digital data transfer methodology allowed on the Amateur bands to date.”

This statement is blatantly designed to mislead the FCC. Again, the information on the SCS web page, more specifically, SCS's own technical description simply refutes this statement in its entirety. Winlink2K is using a commercial modem, designed for the commercial market.

“Therefore, rather than restrict existing bandwidths, which would set digital communications back substantially, I would highly recommend that more attention be given to this type of communications. One only has to look at the rest of the telecommunications industry to see this is necessary for any further development of digital communications.”

One only has to look where the rest of the telecommunications industry is developing digital communications to learn that it is not being done on the HF bands. It is at VHF and above. This claim by Mr. Waterman, indicates his “need for speed”, that is higher speeds and corresponding wider bandwidths is the real issue. Digital communications advancements have been proceeding on the amateur bands through the introduction of many new modes and transmission techniques. New software applications for using these modes have been introduced. This IS all technical innovation that Mr. Waterman refuses to acknowledge because it would weaken his arguments that amateurs have a "need for speed" above all else.

An amateur, Christian Crayton, N5ZAP, recently made a post on a yahoo forum about this subject. His words are appropriate.

"I work daily in information technology, and one sure thing is that an automated message-passing system will, always, without exception and often at an alarming rate, consume all available bandwidth. In my mere 15 years in the industry I have seen communications links start at 300 baud and go all the way to 45 million bits per second and greater. In every case, what was an enormous amount of available bandwidth quickly turned into a bottleneck."

In other words, "the need for speed" becomes a goal unto itself. The current bandwidth will always be completely filled with the need for more. Since amateur spectrum is finite, it must be managed in such a way that no one is disadvantaged more than another. Simply granting those who want wider bandwidths so they can run faster speeds will in the end disadvantage those who don't need the speed more than simply limiting the bandwidth.

"Emergency communications has become a major reason for using the capabilities of Pactor 3 and Winlink 2000. It is often the only thing left after an infrastructure has been destroyed or is otherwise unavailable. It has continuously proven itself successful in real-life casualty events, large and small.

One can only imagine the tragic consequences of learning the valuable lessons of Katrina, the Asian Tsunami, and other such disasters, large and small, only to eliminate the very methodologies that contributed to the saving of lives and property. A subsequent mass casualty event that would follow without such a capability would be difficult to explain in the next Congressional Investigation7. I do fear total congestion of such a capability due mainly to the tremendous growth of stations preparing to use these facilities in any future casualty event. Please assist those who have devoted their experience, time, and resources to this task."

Mr. Waterman would have everyone believe that faster speeds are needed to insure emergency communications are properly provided. One only need access the Winlink2K web site to find out that their "systems" at vhf and uhf utilize amateur AX.25 data transmissions using traditional 1200 bps TNC's. There has been nothing said about these systems being too slow to properly deliver emergency communications in a timely manner. One has to question a claim that faster speeds are needed on the

HF amateur bands when 1200 bps using a scheme that allows multiple stations to share the same frequency (AX.25) at vhf/uhf is apparently functioning very well.

In addition, Mr. Waterman's prose would lead one to believe that amateur radio operators are at the forefront of “saving lives and property”. In truth, very, very few amateur radio operators are trained as first responders and those that are use public agency communication systems. The implication is that public safety communication systems are not up to the task of performing this duty yet amateur radio is. The truth is that amateur communications are used as backups to backups. Are they important, yes. Will there be “tragic consequences” if bandwidth limits on amateur radio data communications are explicitly delineated? It strains credulity especially in light of the Katrina disaster Mr. Waterman mentions. Visions of teams of amateur operators with laptops, pactor modems, hf transceivers and antennas in backpacks trudging into an hurricane flattened area with a generator and fuel slung between them is kind of like seeing sugar plum fairies dancing in your head.

Comments submitted by Todd A. Bowden

“As an active member of numerous emergency response organizations, I cannot begin to state how detrimental this proposal would be to our advancement in emergency communications, a vital part of any response capability. In my experience in emergency medicine and hazardous materials/allhazards response organizations, I rely on new innovative techniques that ham radio operators use to help relay information and communications when other systems fail. But it's not simply when other modes of communication fail. Many of the modes that are threatened by this proposed change are used within our organization as highly effective and reliable means of information exchange on a routine basis - not just to keep practice with using these modes, but because they work so well and form a solid backbone for us to use.

To be specific, some of the agencies that might be affected by this change includes the Tifton Regional Medical center and all members of the Georgia Hospital Association, which includes multiple key organizations spanning public health and medicine capabilities. To be sure, much of Georgia's fire and emergency medical departments also use amateur radio digital modes to augment or back up their communications systems.”

This comment epitomizes one of the most dangerous and egregious use of automatically controlled stations. Many public agencies, non-governmental agencies, and businesses have been purchasing their own amateur equipment, technically for use during emergencies. However, it is obvious that the temptation to use it for regular communications or to augment their communications is very high.

Some part of this is the emphasis by some amateur organizations such as Winlink2K on expanding their organization by pursuing governmental and non-governmental agencies to handle their “emergency traffic”. You only need to peruse some of the amateur web sites and literature to find references to “served agencies” and “meeting customer needs” to understand the overenthusiastic attitudes about this.

The FCC should consider changing Part 97.109(e) to "No station may be automatically controlled while transmitting third party communications not received directly on RF from another amateur station. All messages that are retransmitted must originate at a station that is being locally or remotely controlled."

CONCLUSION

Many claims and comments have been made concerning this petition. The vast majority are unsupported with any facts or computations. They are merely rhetoric designed to elicit an emotional response and little else. These comments should given the weight they deserve, none.

This whole scenario could have been avoided if, prior to deploying these very wide bandwidth commercial modems on the ham bands, an STA process would have been used to develop the information necessary to determine the kind of use, the amount of use, the interference potential, and a myriad of other data. This would have allowed the FCC and others to properly assess the information and determine appropriate rules changes prior to general amateur use. The STA process is an excellent program implemented by the FCC for doing this kind of research and for allowing planned, orderly growth of new technology. What we have instead, is a multi-year unofficial STA with both sides becoming polarized as to whether it should be used or not.

There can be no doubt that the use of Pactor II and Pactor III modems attached to automated stations on the amateur bands, in the fashion they are being used, is creating a major rift in the amateur community. The FCC has indicated in its last Report and Order in 2006 that it expects the rtty/data segments to use narrow data modes. The size of the reduced segments for rtty/data are ample evidence of this. Automated stations using Pactor II and Pactor III outside of the automated sub-bands are without a doubt creating substantial harmful interference. One only need peruse some of the many amateur forums on the internet to see that this is occurring. Even though the evidence is anecdotal, it is substantial and should not be ignored. I urge the FCC to accept the changes made in this petition in order to begin to heal this rift.

James G. Gorman
WA0LYK

APPENDIX A

The PACTOR-III Protocol

Technical Description by Hans-Peter Helfert and Thomas Rink
SCS GmbH & Co. KG, Hanau, Germany

1. Introduction

Similar to PACTOR-I and -II, PACTOR-III is also a half-duplex synchronous ARQ system. In the standard mode, the initial link setup is still performed using the FSK (PACTOR-I) protocol, in order to achieve compatibility to the previous systems. If both stations are capable of PACTOR-III, automatic switching to this highest protocol level is performed.

While PACTOR-I and -II were developed for operation within a bandwidth of 500 Hz, PACTOR-III is designed specifically for the commercial market to provide higher throughput and improved robustness utilizing a complete SSB channel. A maximum of 18 tones spaced at 120 Hz is used in optimum propagation conditions. The highest raw bit rate transferred on the physical protocol layer is 3600 bits/second, corresponding to a net user data rate of 2722.1 bits/second without compression. As different kinds of online data compression are provided, the effective maximum throughput depends on the transferred information, but typically exceeds 5000 bits/second, which is more than 4 times faster than PACTOR-II. At the low SNR edge, PACTOR-III also achieves a higher robustness compared to PACTOR-II.

The ITU emission designator for PACTOR-III is 2K20J2D.

2. Speed Levels and Bandwidth

Depending on the propagation conditions, PACTOR-III utilizes 6 different speed levels (SL), which can be considered as independent sub-protocols with distinct modulation and channel coding. The physical data rate on all speed levels is 100 baud. Up to 18 tones are used, spaced at 120 Hz. The maximum occupied bandwidth is 2.2 kHz (from 400 to 2600 Hz). The center frequency of the entire signal is 1500 Hz. The tone representing the “lowest” channel is sent at a frequency of 480 Hz, the highest tone is 2520 Hz. As tones are skipped on the two lowest speed levels, the gaps between them increase to N times 120 Hz in these cases. The following table illustrates the number and position of the used channels in the different speed levels.

TABLE NOT INCLUDED

Similar to the PACTOR-II protocol, the digital data stream that constitutes a specific virtual carrier is swapped to a different tone with every ARQ cycle in order to increase the diversity gain by adding additional frequency diversity. Considering that in the normal state the numbers of the virtual data carriers correspond with the numbers of the respective tones, the swapped mode assigns carrier 0 with tone 17, 1 with 16, 2 with 9, 3 with 10, 4 with 11, 5 with 12, 6 with 13, 7 with 14 and 8 with 15. Tones 5 and 12 can be considered as equivalent to the two carriers of PACTOR-II, as they transfer the variable packet headers and the control signals (see below).

3. Modulation, Coding and Data Rates

As modulation, either Differential Binary Phase Shift Keying (DBPSK) or Differential Quadrature Phase Shift Keying (DQPSK) is applied. After full-frame bit-interleaving of the entire data packet, an optimum rate 1/2 convolutional code with a constraint length (CL) of 7 or 9 is used. Similar to the PACTOR-II protocol, the codes with higher rates, i.e. rate 3/4 and rate 8/9, are derived from that code by so-called puncturing: Prior to the transmission, certain of the symbols of the rate 1/2 encoded stream are “punctured”, i.e. deleted and thus not transmitted. At the receiving side, the punctured encoded bits are replaced with “null” symbols prior to decoding with the rate 1/2 decoder. The decoder treats these null symbols neither as a received “1” nor as “0”, but as an exactly intermediate value. No information is thus conveyed by that symbol that may influence the decoding process. The coding performance of “punctured” code operation nearly matches the coding performance of the best known classic rate 3/4 or 8/9 codes with a comparable constraint length, provided that the puncture pattern is chosen carefully. The major advantage of this approach is that a single code rate decoder (in our case a rate 1/2 decoder) can implement a wide range of codes. In the SCS modems, a real Viterbi decoder with soft decision is utilized for all speed levels, providing a maximum of coding gain.

The following table shows the modulation, the constraint length (CL) and the code rate (CR) of the applied convolutional code, the physical data rate (PDR), i.e. the raw bit rate transferred on the physical protocol layer, the net data rate (NDR), i.e. the uncompressed user data rate, as well as the crest factor (CFR) of the signal in the different speed levels (SL).

TABLE NOT INCLUDED

3. Cycle Duration

The ARQ cycle durations are still 1.25 seconds (short cycles) and 3.75 seconds (data mode), which is one of the requirements to obtain easy compatibility to the previous PACTOR standards. Due to signal propagation and equipment switching delays, PACTOR-III, similar to the preceding PACTOR protocols, has in this standard mode a maximum range for ARQ contacts of around 20,000 km. Therefore, a long path option is again available, enabling contacts up to 40,000 km, with cycle times of 1.4 seconds (short cycles) and 4.2 seconds (data mode), respectively. The sending station initiates a connect in 'Long Path Mode' by inverting the first byte of the callsign in the FSK connect frame (for details, see the PACTOR-I protocol description).

4. Structure of Packets and Control Signals

Except from different data field lengths, the basic PACTOR-III packet structure is similar to the previous PACTOR modes. It consists of a packet header, a variable data field, the status byte and the CRC. Two types of headers are used: Sixteen “variable packet headers” consisting of 8 symbols each are sent alternately on tones 5 and 12 to code 4 bit of information: Bit

0 defines the request-status indicating a repeated packet. Bits 2 and 3 specify the speed levels 1 to 4 according to the modulo-4 logic, whereas the detection of levels 5 and 6 is performed by additionally analyzing the constant packet headers. Bit 4 gives the current cycle duration: “0” specifies short and “1” long cycles. The following table shows the hexadecimal codes of the variable packet headers.

TABLE NOT INCLUDED

The remaining tones 1-4, 6-11 and 13-18 are preceded by constant headers that characterize the respective tones without transferring any additional information. They support QRG tracking, Memory-ARQ, the Listen-Mode and the detection of the speed levels 5 and 6. The table below presents the hexadecimal codes of the constant packet headers.

TABLE NOT INCLUDED

The headers are followed by the data fields that transfer the user information. On the 6 different speed levels, 5, 23, 59, 122, 212 and 284 usable bytes are transferred in the short cycle and 36, 116, 276, 556, 956 and 1276 in the long cycle, respectively. After de-interleaving and decoding of the entire data transferred on all tones within a certain cycle, the actual information packet is obtained, which consists of the user data, a status byte and the 2 CRC bytes.
The status byte characterizes the packet by a two-bit packet counter to detect repetitions (bit 0 and 1), provides information on the applied data compression (bits 2, 3 and 4), suggests to switch to the data mode when the amount of characters in the transmit buffer exceeds a certain number (bit 5), indicates a changeover request (bit 6) and initiates the QRT protocol (bit 7). For details, see the graphic below. The final part of the packet is a 16-bit CRC calculated according to the CCITT-CRC16 standard.

PACTOR-III uses the same set of six 20-bit Control Signals (CS) as PACTOR-II. They are transmitted simultaneously on the tones 5 and 12 and all have the maximum possible mutual hamming distance to each other. Hence they reach exactly the Plotkin boundary and represent a perfect code. This allows the advantageous use of the Cross Correlation method for decoding, a kind of soft decision that leads to the correct detection of even inaudible CS. CS1 and CS2 are used to acknowledge/request packets and CS3 forces a break-in. CS4 and CS5 handle the speed changes: CS4 demands an increase of the speed to the next higher level. CS5 acts as a NACK asking for a repetition of the previously sent packet and at the same time for a reduction of the speed to the next lower level. CS6 is a toggle for the packet length and inquires a change to long cycles in case that the actual state is short cycles and vice versa. All CS are always sent in DBPSK in order to obtain maximum robustness.

The graphic below illustrates the entire PACTOR-III cycle.

GRAPHIC NOT INCLUDED

5. On-line Data Compression

Like in the previous PACTOR modes, automatic on-line data compression is also applied in the PACTOR-III protocol, comprising Huffman and run-length encoding as well as Pseudo-Markov Compression (PMC, see below). The information sending system automatically checks, whether one of those or the original ASCII code leads to the shortest data package, which depends on the probability of occurrence of the characters. There is hence no risk of losing throughput capacity. Of course PACTOR-III is still able to transfer any given binary information, e.g. programs or picture- and voice files. In case of binary data transfer, the online data compression normally switches off automatically due to the character distribution. An external data compression in the terminal program is usually performed instead.

Huffman compression exploits the "one-dimensional" probability distribution of the characters in plain texts. The more frequently a character occurs, the shorter has to be its Huffman symbol. More details including the code table used in the PACTOR protocols can be found in the description of the PACTOR-I standard.

Markov compression can be considered as a "double" Huffman compression, since it not only makes use of the simple probability distribution, but of the "two-dimensional" probability. For each preceding character, a probability distribution of the very next character can be calculated. For example, if the actual character is "e", it is very likely that "i" or "s" occurs next, but extremely unlikely that an "X" follows. The resulting probability distributions are much sharper than the simple one-dimensional distribution and thus lead to a considerably better compression. Unfortunately, there are two drawbacks: Since for each ASCII character a separate coding table is required, the entire Markov coding table becomes impractically large. Additionally, the two-dimensional distribution and thus also the achievable compression factor depends much more on the kind of text than the simple character distribution. We have therefore chosen a slightly modified approach which we called Pseudo-Markov Compression (PMC), because it can be considered as a hybrid between Markov- and Huffman encoding. In this variant, the Markov encoding is limited to the 16 most frequent "preceding" characters. All other characters trigger normal Huffman compression of the very next character. This reduces the Markov coding table to a reasonable size and also makes the character probabilities less critical, since especially the less frequent characters tend to have unstable probability distributions. Nevertheless, for optimum compression, two different tables for English and German texts are defined in the PACTOR-II and -III protocols and automatically chosen. When transferring plain text, PMC yields a compression factor of around 1.9 compared to 8-bit ASCII.

Run-length encoding allows the effective compression of longer sequences of identical bytes. The special prefix byte “0x1D” is defined, which initiates the 3 byte run length code. The second byte is called the “code byte” and contains the original code of the transferred byte within the range of the entire ASCII character set. The third byte provides the number of code bytes to be displayed on the receiving side within the range between “0x01” to “0x60”. Values between “0x00” and “0x1f” are transferred as “0x60” to “0x7f”, values between “0x20” and “0x60” are transferred without any change. If, for example, the sequence “AAAAAAAA” should be transferred, the respective 3 byte run-length code would be “0x1D 0x41 0x68”.

6. Signal Characteristics and Practical Considerations

As the FSK PACTOR standard is used for the initial link establishment, frequency deviations of the connecting stations of up to +/–80 Hz are still tolerated. Similar to the PACTOR-II mode, a powerful tracking algorithm is provided in the SCS modems to compensate any divergence and exactly match the signals when switching to the DPSK mode, which requires a high frequency accuracy and stability.

The PACTOR-III signal provides a very high slope steepness in order to avoid any spillover in adjacent channels. Therefore, low quality audio filters may lead to a distortion of the side tones of the signal on the higher speed levels on the transmitting as well as on the receiving side. To partly compensate for that, SCS modems allow the amplitude of the signal edges to be enhanced individually in two steps using the “Equalize” command, which defines the function of the PACTOR-III transmit equalizer. A value of “0” switches this function off, “1” means a moderate, and “2” a strong enhancement of the side tones of the signal.

Further, it has to be taken into consideration, that, due to the different possible “tones” settings relating to the FSK mode used for the initial link setup, a shift of the center frequency of the signal may occur with the automatic switching to PACTOR-III. Therefore, the “tones” settings should be checked carefully and adapted to the other stations in the network in order to make sure that no offset occurs between the linked stations and the PACTOR-III signal is placed symmetrically within the filter bandwidth. Usually, identical “tones” settings on both sides of a PACTOR-III link are required for proper operation. SCS recommends to set “tones” to “4”, defining the FSK connect tones as 1400 and 1600 Hz, which are balanced around the PACTOR-III center frequency of 1500 Hz, to avoid incompatibilities between PACTOR-III users.

The following figure shows a spectrum of the PACTOR-III signal on speed level 6 with all 18 tones.

FIGURE NOT INCLUDED